S4

SMALL SATELLITES FOR SECONDARY STUDENTS

Introduction to Payload Elements

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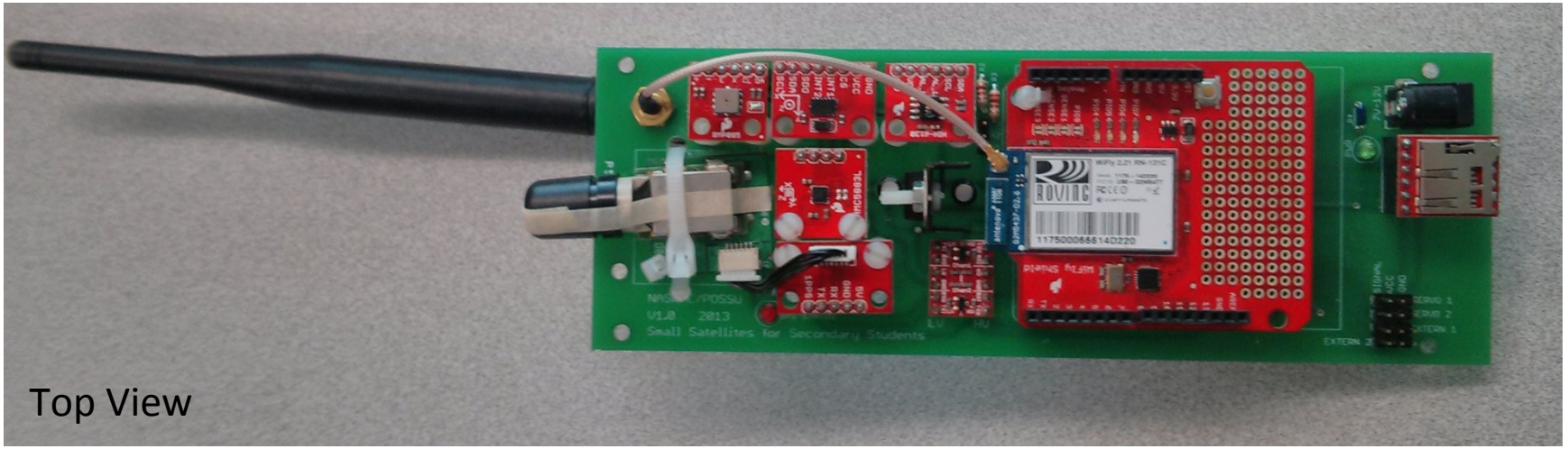
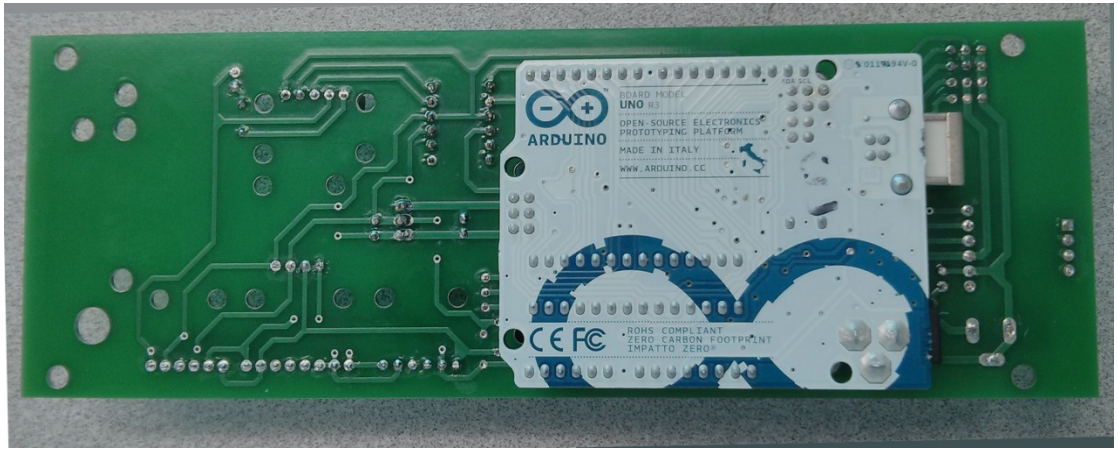
Complete Payload



Top View

Design Philosophy

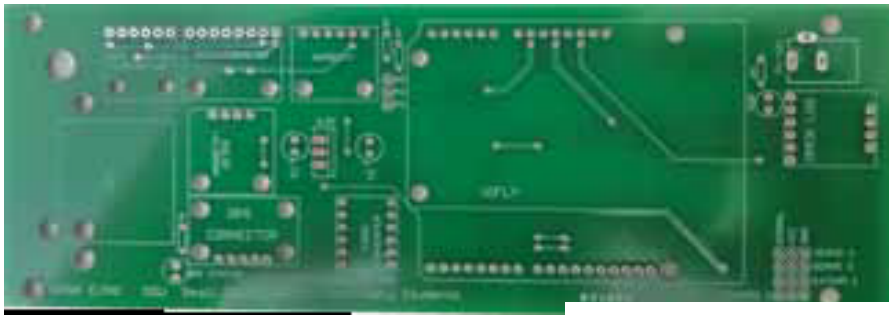
- Open Hardware
- Open Software
- Off the shelf parts
- Minimal soldering
- Designed to fit in 3” diameter rocket/ balloon
- Light weight



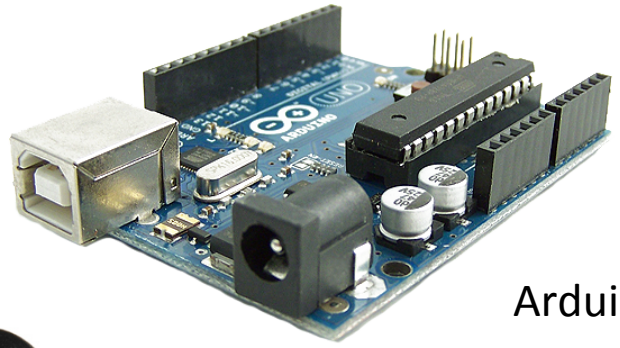
Bottom View

Base Payload Components

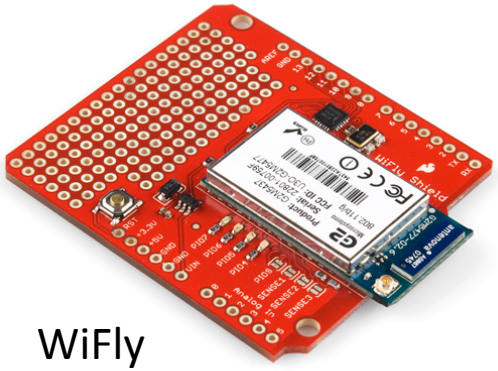
Required on every payload



Flight board



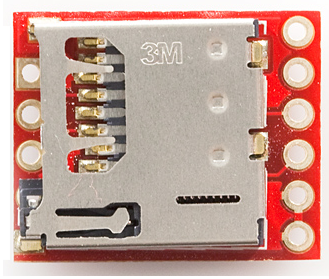
Arduino



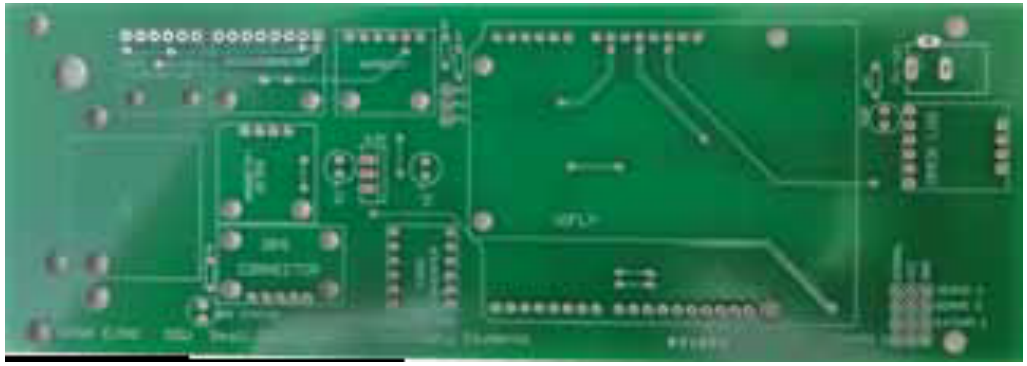
WiFly

GPS

Open Log

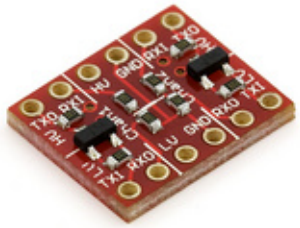


Flight Board



- Printed Circuit Board (PCB)
- NOT off the shelf (yet) provided by us
- Physical backbone of the payload
- Facilitates power and communication between payload components
- Requires soldering skill to assemble
- Does not require soldering skill to attach components once assembled
- Manufacturing partner for assembly?

Major Subcomponents

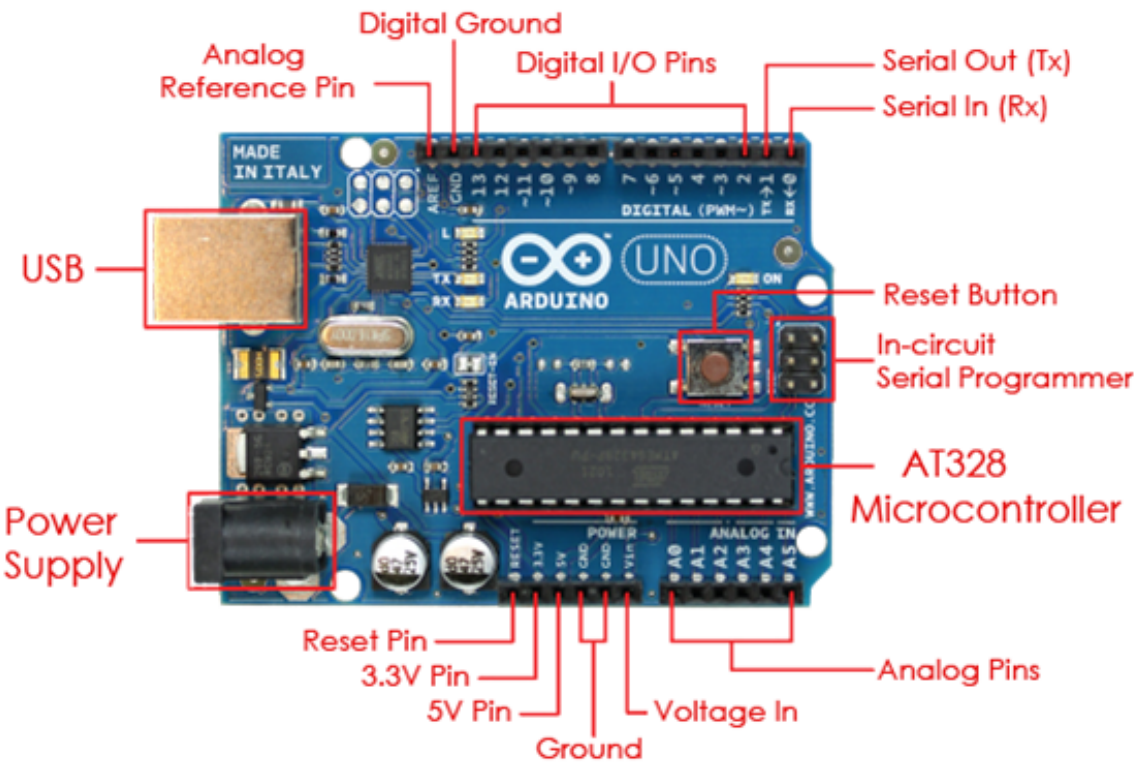


Logic Level Converter – Steps 5V source from Arduino down to 3.3V source for payload components

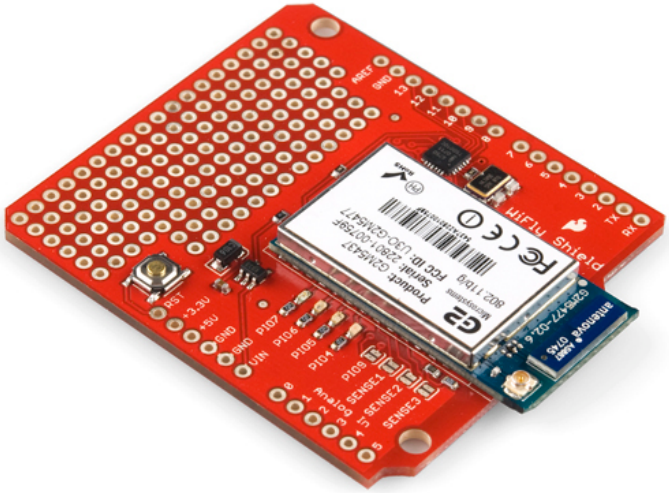
Voltage Regulator – protects payload components from over-voltage. Dissipates extra energy as heat.

Arduino

- Facilitates Communication with other payload components
- Programmable, runs the code that we write
- Mounts to *bottom* of flight board
- Can be used in many other hardware applications
- Well supported by Maker/ Open Hardware movement



WiFly



- Same type of Wi-Fi as computers and cell phones (802.11 b/g)
- Example of an Arduino Shield (shares pins with Arduino)
- Prototyping holes (unused)
- Maintain real-time telemetry throughout the flight
- Must be configured with network information

- Duck antenna improves signal
- Orientation not particularly important
- Not needed for classroom testing

Global Positioning System (GPS)

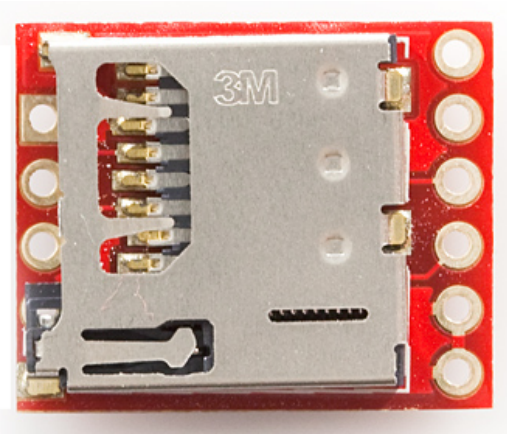
- Determine Latitude, Longitude, Altitude and Time for payload data points
- Same type of GPS as cell phones and Navigation
- Requires satellite signal to lock
- Lock can take up to two minutes
- Careful, it's expensive

```
$GPGGA,210044.00,3820.39934,N,12240.61207,W,1,06,1.78,55.0,M,-29.2,M,,*5B
$GPGGA,210045.00,3820.39922,N,12240.61234,W,1,06,1.78,55.9,M,-29.2,M,,*54
$GPGGA,210046.00,3820.39839,N,12240.61260,W,1,06,1.78,56.4,M,-29.2,M,,*53
$GPGGA,210047.00,3820.39784,N,12240.61293,W,1,06,1.78,56.4,M,-29.2,M,,*57
$GPGGA,210048.00,3820.39738,N,12240.61346,W,1,06,1.78,56.4,M,-29.2,M,,*56
$GPGGA,210049.00,3820.39682,N,12240.61368,W,1,06,1.78,56.9,M,-29.2,M,,*56
$GPGGA,210050.00,3820.39660,N,12240.61340,W,1,06,1.78,57.1,M,-29.2,M,,*51
$GPGGA,210051.00,3820.39646,N,12240.61307,W,1,05,5.23,56.9,M,-29.2,M,,*57
```

Open Log

- Collect and store data without need for wireless networking
- Maintain data collection if and when wireless signal lost
- Same type of micro SD as cell phones
- Writes to a plain text file
- SD card reader and micro to standard adapter needed to recover data

```
<sensor>PayloadName,data,1
<sensor>PayloadName,data,1
<sensor>PayloadName,data,1
<sensor>PayloadName,data,1
<sensor>PayloadName,data,1
<sensor>PayloadName,data,1
<sensor>PayloadName,data,1
<sensor>PayloadName,data,1
<sensor>PayloadName,data,1
```

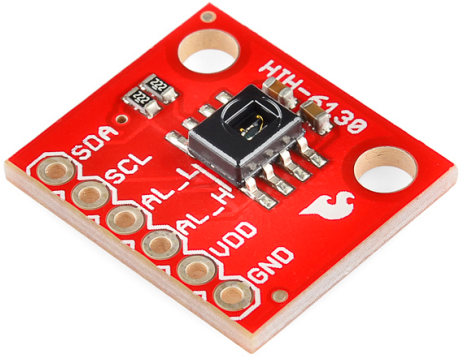


Extended Payload Components

Optional on Payloads

Accelerometer

Magnetometer



Humidity and Temperature

Barometric Pressure
And Temperature

Accelerometer

- Returns 3-axis acceleration data (x,y,z)
- Will measure force of gravity
- Returns acceleration in g
- Maximum acceleration measurement of about 16g

```
Accel X: -0.01g  Accel Y: -0.61g  Accel Z: 0.74g
Accel X: -0.02g  Accel Y: -0.62g  Accel Z: 0.75g
Accel X: -0.02g  Accel Y: -0.62g  Accel Z: 0.75g
Accel X: -0.02g  Accel Y: -0.62g  Accel Z: 0.74g
Accel X: -0.01g  Accel Y: -0.61g  Accel Z: 0.74g
Accel X: -0.01g  Accel Y: -0.61g  Accel Z: 0.75g
Accel X: -0.02g  Accel Y: -0.61g  Accel Z: 0.75g
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Accel X: -0.02g  Accel Y: -0.62g  Accel Z: 0.74g
Accel X: -0.01g  Accel Y: -0.62g  Accel Z: 0.74g
Accel X: -0.02g  Accel Y: -0.62g  Accel Z: 0.74g
Accel X: -0.01g  Accel Y: -0.61g  Accel Z: 0.74g
Accel X: -0.01g  Accel Y: -0.61g  Accel Z: 0.75g
```

Magnetometer

- Returns 3-axis magnetic field data (x,y,z)
- Will measure Earth's magnetic field
- Returns values of 10^{-5} Tesla

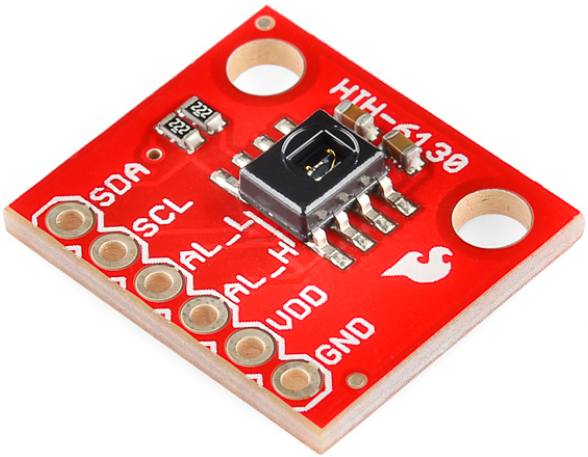
```
Mag X: -346  x10^-5 Tesla   Mag Y: -91  x10^-5 Tesla   Mag Z: -164  x10^-5 Tesla
Mag X: -346  x10^-5 Tesla   Mag Y: -91  x10^-5 Tesla   Mag Z: -164  x10^-5 Tesla
Mag X: -344  x10^-5 Tesla   Mag Y: -93  x10^-5 Tesla   Mag Z: -162  x10^-5 Tesla
Mag X: -348  x10^-5 Tesla   Mag Y: -91  x10^-5 Tesla   Mag Z: -161  x10^-5 Tesla
Mag X: -345  x10^-5 Tesla   Mag Y: -92  x10^-5 Tesla   Mag Z: -161  x10^-5 Tesla
Mag X: -344  x10^-5 Tesla   Mag Y: -91  x10^-5 Tesla   Mag Z: -163  x10^-5 Tesla
Mag X: -345  x10^-5 Tesla   Mag Y: -94  x10^-5 Tesla   Mag Z: -163  x10^-5 Tesla
Mag X: -344  x10^-5 Tesla   Mag Y: -94  x10^-5 Tesla   Mag Z: -162  x10^-5 Tesla
Mag X: -342  x10^-5 Tesla   Mag Y: -93  x10^-5 Tesla   Mag Z: -167  x10^-5 Tesla
```

Barometric Pressure and Temperature

- Returns a separate pressure and temperature readings
- Pressure measured in Pascals
- Temperature measured in degrees Celsius
- Often used for determining altitude

```
Pressure: 100602 Pascals      Temperature: 24.00 degrees Celsius
Pressure: 100602 Pascals      Temperature: 24.00 degrees Celsius
Pressure: 100598 Pascals      Temperature: 24.00 degrees Celsius
Pressure: 100599 Pascals      Temperature: 24.00 degrees Celsius
Pressure: 100595 Pascals      Temperature: 24.00 degrees Celsius
Pressure: 100601 Pascals      Temperature: 24.00 degrees Celsius
Pressure: 100602 Pascals      Temperature: 24.00 degrees Celsius
Pressure: 100611 Pascals      Temperature: 24.00 degrees Celsius
Pressure: 100599 Pascals      Temperature: 24.00 degrees Celsius
Pressure: 100606 Pascals      Temperature: 24.00 degrees Celsius
Pressure: 100604 Pascals      Temperature: 24.00 degrees Celsius
Pressure: 100598 Pascals      Temperature: 24.00 degrees Celsius
```

Humidity and Temperature



- Returns separate humidity and temperature readings
- Humidity in relative percentage
- Temperature measured in degrees Celsius
- Some redundancy with other temp sensor

```
Humidity: 61.93 relative %   Temperature: 23.66 degrees Celsius
Humidity: 61.93 relative %   Temperature: 23.68 degrees Celsius
Humidity: 61.93 relative %   Temperature: 23.69 degrees Celsius
Humidity: 61.93 relative %   Temperature: 23.68 degrees Celsius
Humidity: 61.93 relative %   Temperature: 23.69 degrees Celsius
Humidity: 61.93 relative %   Temperature: 23.69 degrees Celsius
Humidity: 61.90 relative %   Temperature: 23.69 degrees Celsius
Humidity: 61.90 relative %   Temperature: 23.69 degrees Celsius
Humidity: 61.88 relative %   Temperature: 23.69 degrees Celsius
Humidity: 61.88 relative %   Temperature: 23.69 degrees Celsius
Humidity: 61.86 relative %   Temperature: 23.69 degrees Celsius
```

Conclusion

References:

Parts:
http://www.sparkfun.com

Arduino Playground:
http://playground.arduino.cc/